70th International Astronautical Congress (IAC), Washington DC, USA, 21-25 October 2019.

IAC-19-B.3.3.1

Impact of the international Space Station Research Results

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Abstract

The International Space Station (ISS) facilitates research that benefits human lives on Earth and serves as the primary testing ground for technology development to sustain life in the extreme environment of space. To date, investigators have published a wide range of ISS science results, from improved theories about the creation of stars to the outcome of data mining "omics" repositories of previously completed ISS investigations. Because of the unique microgravity environment of the ISS laboratory and the multidisciplinary and international nature of the research, analyzing ISS scientific impacts is an exceptional challenge. As a result, the ISS Program Science Forum (PSF), made up of senior science representatives across the ISS international partnership, uses various methods to describe the impacts of ISS research activities. For the most part, past papers written by PSF members to assess the overall ISS research impact have focused on exhibiting ISS research impact by quantifying ISS research output or its perceived benefits for humanity.

This paper proposes a new assessment of ISS impact from the perspective of the end users' needs. To that end, the authors use visualizations and metrics of scientific publication data to show the ISS research influence on traditional scientific fields, its global reach and the benefits to people across the globe.

Keywords: (maximum 6 keywords): ISS, microgravity, Visualization, Term Map, Keyword Map, Average number of Citations Per Article

Acronyms/Abbreviations

Average number of citations per article (ACPA), International Space Station (ISS), Journal Impact Factor (JIF), Not applicable (N/A), Program Science Forum (PSF), Subject Matter Expert (SME), Web of Sciences (WOS)

1. Introduction

Assessing the scientific impact of a laboratory within a research realm as unique as the International Space Station (ISS) has always been challenging.

In the past, ISS Program Science Forum members' publications on the impact of the space station have covered subjects such as Expanded benefits for humanity from the International Space Station [1], ISS research results and accomplishment output [2], Benefits of International Collaboration of the ISS [3], assessing ISS benefits for humanity [4], or the yearly Annual Highlight of Results from the International Space Station reports [5-7]. All these publications rely on ISS research output to gauge the impact of the International Space Station on the scientific community. In this paper, the authors propose to look at the ISS impact from another perspective. The intent is to measure ISS impact by considering the users' perspective. The use of ISS research publications by the scientific community is measured through qualitative and quantitative means.

We assume a measure of the value or influence of a peer-reviewed scientific publication can be quantified through how often other authors have used it as reference. Furthermore, because the number of times an article is cited could vary widely depending on the field of discipline (e.g. Life Sciences research papers tend to garner greater number of citations overall compared to papers in the field of mathematics [8, 9]), the assessment of publication relative importance through citation count should be performed within specific disciplines or sub-disciplines.

In this paper, the authors assess the breadth and depth of ISS research output by reviewing several citation-focused metrics. As of April 19, 2019, there were over 1400 peer-reviewed ISS research publications identified using the Clarivate Analytic's Web of Science database. Collectively, those 1400+ publications were cited more than 13,800 times in peer-reviewed literature, including journal articles, conferences proceeding articles, and books. That data serves as the foundation to perform qualitative and quantitative analyses presented in the remainder of this paper, which is organized into four main sections.

The first section provides an evaluation of the breadth of ISS reach through the global diversity of authors who have relied on the space station's research findings for their peer-reviewed publications by looking at their national origin. The second section relies on visualization maps to show both the breadth and depth of the influence of ISS research on scientific disciplines and sub-disciplines where ISS results serve as a reference. The third section presents a qualitative assessment of ISS publications compared to peers' publications in the same journals. And finally, we present a brief conclusion to summarize the paper and lessons learned.

2. ISS Global Reach

Since publication of ISS-related research began in February 2002 through April 19, 2019, over 13,800 other publications – as indexed by Web of Science and composed of peer-reviewed journal articles, conference papers, and books – were found to have cited an ISS publication as a reference. Although ISS investigations are primarily centered around microgravity-related research, authors who have cited ISS publications have published in a wide range of disciplines, including biological sciences, physical science, and social science. In past publications, the ISS Program Science Forum (ISS PSF) has highlighted the diversity of scientific fields impacted by the ISS research output [10]. In this section, the authors intend to gauge the reach of ISS research by reviewing the national origin of authors who have relied on ISS research results.

Scientific disciplines can be organized in a variety of ways. This paper adopts the ISS PSF categorization method. Traditionally, the PSF divides ISS publications into six (6) categories: Earth and Space Sciences; Physical Sciences, Biology and Biotechnology Sciences; Human Research, Technology Development and Demonstration; and Educational and Cultural Activities. However, due to the similarity between some of the disciplines in non-space related fields of research and to avoid potential ambiguity from having to classify over 13,800 publications that have cited ISS research results as a reference, the authors have adopted a modified discipline classification by reorganizing the original category classification into three main groups: Physical Sciences (which combines the original Earth and Space Sciences plus the Physical Sciences); Biological Sciences (which combines Human Research plus Biology and Biotechnology Sciences); and Technology Development and Demonstration. The rationale for this reclassification is that several ISS findings in a given PSF category maybe cited by authors in a totally area of research. For example many ISS publications in the the PSF's Earth and Space Science category are referenced by citing-authors in the field of Optics, which is a sub-category of terrestrial physical science research.

The discipline of Educational and Cultural Activities is excluded due to the limited number of publications in the field. The rest of this section shows the global spread and the concentration per country of authors who cited ISS research through heat maps for the Physical Sciences, Biological Sciences and Technology Development and Demonstrations.

2.1 Physical Sciences Disciplines

In the field of Physical Sciences, using data obtained from the Web of Science database, 10,413 authors and co-authors from 105 countries and territories were found to have cited at least one ISS research publication in their peer-reviewed publications. The heat map in Fig. 1 represents the reach of the ISS research results on a global scale through the spread and number of authors whose publications reference ISS research results publications.

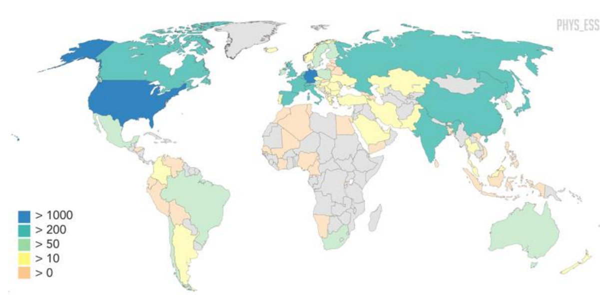

Fig. 1. Heat Map for Physical Sciences

The highest number of authors and co-authors citing ISS research in terms of their national origin are the United States of America with 1790 (17%), followed by Germany with 1179 (11%), China 809 (7.8%), France 649 (6%), Japan 607 (5.8%) and Italy 579 (5.6%). Although authors from only these six nations represent 54% of all of authors and co-authors who cited ISS work, ISS research output in the field of Physical Science have been used by authors and co-authors across every continent as illustrated in Fig. 1.

2.2 Biological Sciences Disciplines

Similarly to the field of Physical Sciences, ISS research results have been prominently used for Biological Sciences as well. The heat map in Fig. 2 represents 10,639 authors and co-authors from 95 countries and territories who have published peer-reviewed papers in the Biological Science field while citing at least one ISS research publication as a reference.

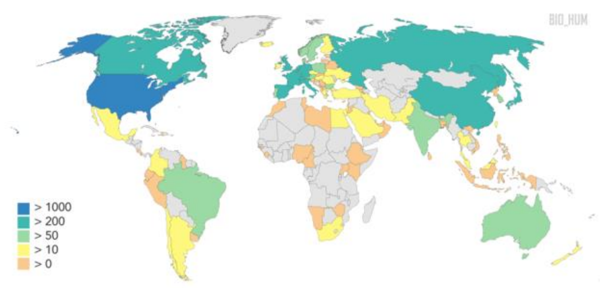

Fig. 2. Heat Map for Biological Sciences

The illustration in Fig. 2 shows that authors from every continent have relied on ISS findings in the publication of their own peer-reviewed articles. Not unexpectedly, the ISS partner countries have used ISS findings the most. The USA tops the list with the highest number of ISS-citing authors at over 3,250 (30.6%). The remaining countries in the top five are Japan with 722 (6.8%), China with 603 (5.7%), Italy with 566 (5.3%) and UK with 549 (5.2%) ISS-citing authors and co-authors.

2.3 Technology Demonstration

Compared to the Physical Sciences and the Biological Sciences, ISS research publications in the discipline of Technology Development and Demonstration have relatively fewer citations. This fact is understandable, given that articles in Technology Development and Demonstration do not usually discuss fundamental research. Yet as shown on the heat map in Fig. 3, there are 1734 authors who have cited an ISS Technology Development and Demonstration-related articles as a reference in their publications. Those citing authors span 60 countries and territories, representing every continent. With 450 authors and co-authors, the USA has the highest number of authors who cited an ISS peer-reviewed article from the Technology Development and Demonstration field, followed by China with almost 200 authors.

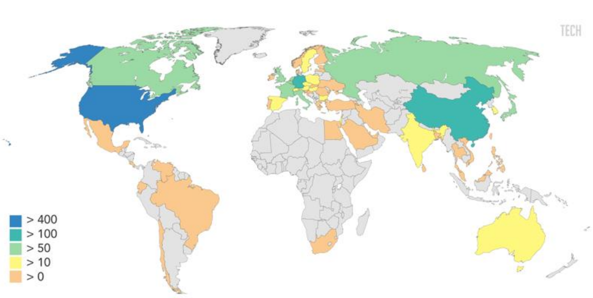

Fig. 3. Heat Map for Technology Demonstration

Through these three heat maps, it is evident that ISS scientific output has a global impact and is used by authors far beyond ISS-partner countries, with the use of ISS Physical Science representing the broadest reach.

3. ISS Impact (Influence)

3.1 VOSviewer Visualizations

Another way to evaluate ISS influence on the scientific community is to review and characterise disciplines and sub-disciplines of publications that have relied on ISS findings. To that end, the visualization software tool VOSviewer developed by the Centre for Science and Technology Studies (CWTS) at Leiden University in the Netherlands [11] is used to create Term Maps and Keywords Maps to show the major disciplines and sub-disciplines where authors cited an ISS published article in their peer-reviewed publication. VOSviewer is a tool that is primarily used for analyzing bibliometric data and illustrating network relationships that may exist.

Term Maps and Keywords Maps are powerful and intuitive visualization tools. They use the content of article titles and abstracts for the Term Maps, and keywords for the Keyword Maps to provide insights such as major research areas (clusters), the relative importance of a field of research (size of items), the relationship if any between fields of research (link). Each cluster, characterized by a given color, is composed of cells that represent sub-disciplines. The size of each cell represents the sub-discipline weight or its relative importance within that cluster. The relative distance between two cells represents their relatedness. That is, the closer they are in term of distance, the more related the two disciplines are in terms of co-citation links. A line between two cells signifies a link between them. Only the 1000 strongest links are shown on the map.

Another advantage of this visualization method is that Term Maps and Keywords Maps help address the ongoing challenge of matching publications with the correct discipline when articles are published in a journal classified as a discipline different from the contents of the discipline of the referenced paper. For example, Web of Science classifies PLOS One under the infectious disease discipline, whereas several articles published byPLOS One are of completely different disciplines. With the Term Maps and Keyword Maps, the classification of articles is no longer based on the type of journal in which a peer-reviewed article appears but instead on the content of the article itself.

In the following sections, the Term Maps and Keyword Maps were created using bibliometric data obtained by pulling all the peer-reviewed publications where an ISS article was used as a reference from of the Web of Sciences (WOS) database.

3.2 Term Maps

To create the Term Maps, the authors built a database composed of the same data for over 13,800 peer-reviewed publications that cited an ISS article from above. The VOSviewer software tool read through the formatted form of the titles and abstracts of each publication in Web of Sciences and extracted key terms based on their frequency of appearance. That database was used as the input for the analysis [12].

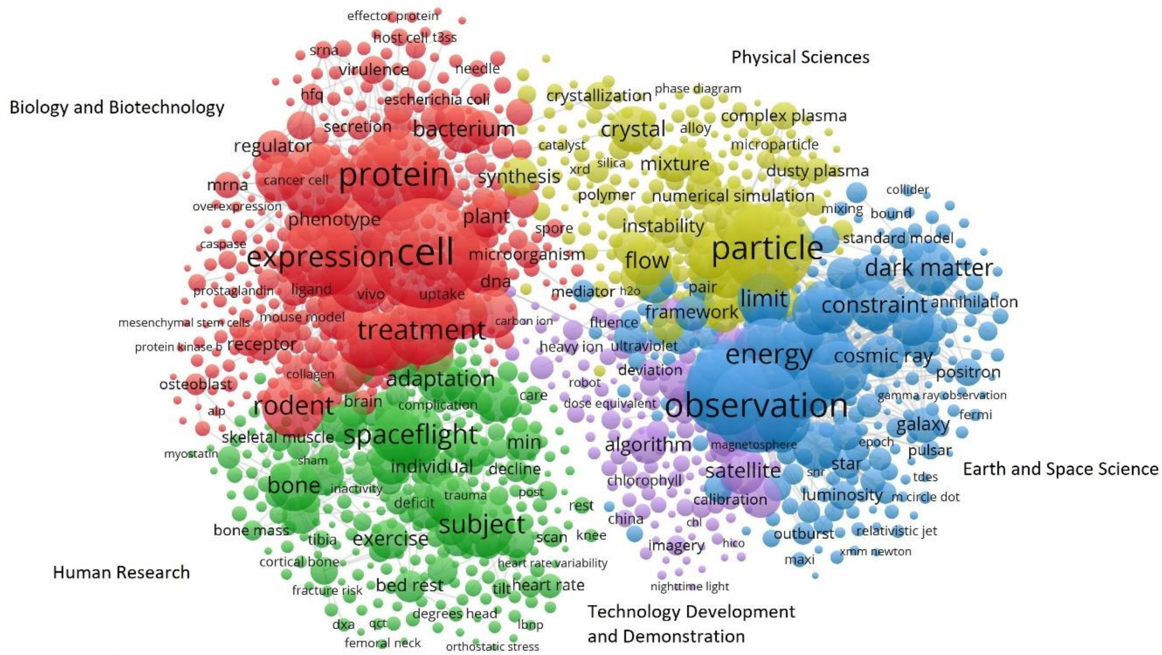

Fig. 4. Term Map of publications that cited an ISS publication

The developers of the VOSviewer software tool recommend setting the number of occurrences such that the total number of terms to be included in the analysis would be a maximum of 2,500 terms. Thus, setting the threshold at 25 yielded 2389 distinct terms for this analysis; that is, any item that did not appear at least 25 times was excluded from the map.

The Term Map shown in Fig. 4 represents a collection of words (items) that recurred through the titles and abstracts of papers that used an ISS research output as a reference. The software automatically grouped the results in five (5) main categories or clusters based on the similarity of the area research. Each cluster (colored distinctly) represents a major area of scientific research. PSF Subject Matter Expert (SME) judgements were used to provide the appropriate label for each cluster. The Biology and Biotechnology sciences (red) cluster is relatively closer to the Human Research (green) than to the discipline of Astrophysics, for example. This proximity between the two Life Science clusters means that there exists a greater number of articles with co-citations between them as compared with Astrophysics papers. Similarly, the Space Science cluster and the Astrophysics cluster have several overlapping items.

The Term Maps in Fig. 4 highlight the importance of specific terms in publications that cite ISS research, displaying the extent of the ISS impact on sub-disciplines.

3.3 Keyword Maps

The Keyword Maps are very similar to the Term Maps in the sense that both maps are made with words directly collected from the articles themselves. The main difference between the two maps is the source of the data used to build them. As its name indicates, Keyword Maps use Web of Science Keywords Plus options. Unlike Term Maps, which rely on words used by the papers' original authors, Keywords Plus are the keywords that subject matter experts at Clarivate's Web of Science attribute to each paper that they deem to be appropriate to characterize the paper's content in addition to the keywords provided by the authors, when available.

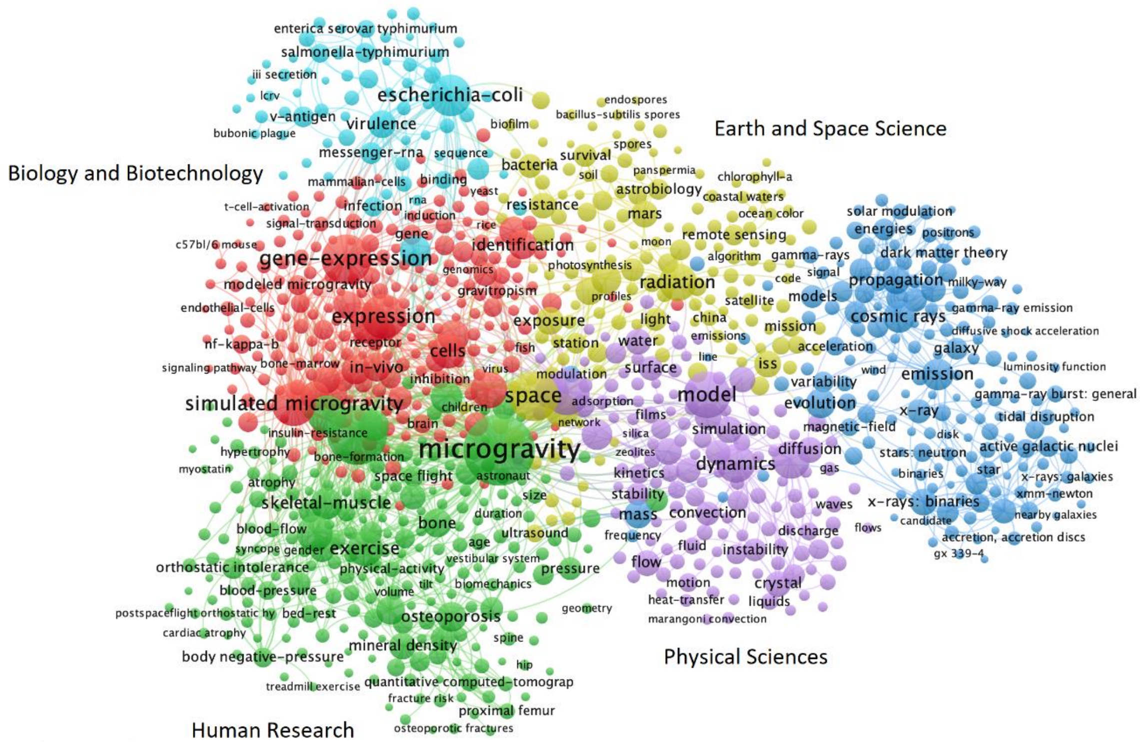

Fig. 5. Keyword Map of publications that cited an ISS publication

The Keyword Map shown in Fig. 5 represents over 13,800 articles where an ISS publication was cited. A threshold of 10 occurrences of keywords was set such that any keyword that did not appear at least 10 times was eliminated from the map. The determination of the value of the threshold is based on the VOSviewer software tool developers' recommendation that the number of terms that meet the threshold should not exceed 2500. This allows for visually cleaner maps. With a threshold value set at 10, there were 2435 terms for this Keywords Map evaluation. Further, words and abbreviations whose meanings were ambiguous were disambiguated. The results yield six (6) clusters (Biology and Biotechnology, Human Research, Microbiology, Remote Sensing, Astrophysics, and Physical Science). Compared to the Term Maps, the Keyword Maps in Fig. 5 mostly refines the biological and human research clusters to generate an extra cluster labelled Microbiology.

These two maps show the extent to which ISS research output has been used thus far by the scientific community. Authors who have cited ISS researcher publications perform research not only in the core research areas of ISS, but also beyond active fields of ISS research. It is worth noting a major advantage of performing bibliometric analyses using VOSviewer's Term Maps and Keyword Maps over other visualization techniques such as Map of Science: VOSviewer maps use the contents of articles to determine discipline categorizations (into given clusters) rather than trusting the pre-defined discipline of the journal in which they are published [13].

4. Impact of Individual ISS Publications

It is known and accepted in the scientific community that the number of times a peer-reviewed article of a journal is cited can represent the journal's overall impact, known as the Journal Impact Factor (JIF) [14]. JIF is defined as the yearly number of citations of articles published in a journal during the two preceding years, divided by the total number of "citable items" published in that journal during the two preceding years. The JIF only measures the perceived impact of the journal, not the impact of the individual articles contained within the journal.

Even more holistic bibliometric metrics such the Clarivate Analytics' Eigenfactor only provide a ranking of journals by importance, but does not rank article importance. Many publications in the field of Bibliometrics and Scientometrics have made the case for the use of alternative metrics to JIF to quantify per-reviewed articles [15,16]. Nevertheless, JIF has remained popular in part because of its ease of calculation based on number of citations and the merit of using readily available citation count as relative for general interest. However, to ensure objectivity, if citations-based metrics were to be used as a measure of influence, authors recommend that only articles within the same field of research should be compared. [8]

A measurement of the overall impact of an article could be determined by comparing the number of times that article has been cited relative to its peers within a given discipline or sub-discipline. It is proposed in this paper to assess ISS research impact by comparing ISS research publications with their peers.

A metric of the quality of ISS publications can be defined as the average number of citations of ISS research papers compared to the average citation of all papers in the same source for a given year. An article-specific metric, such as the average number of citations per article, has the advantage of providing a glance into the paper's relative importance rather than a metric such as the Journal Impact Factor, which characterizes readers' interest in a given journal.

The average number of citations per article (ACPA) is calculated for ISS research publications and for non-ISS publications in the same journal following the methodology outlined in the next section.

4.1 Methodology of calculation

In this section, a method to calculate the metric, "average number of citations per article since publication" of ISS and non-ISS articles is as follows:

1) Sources: For a given PSF category of discipline (e.g., Earth and Space Science), locate all of the sources (journals) where ISS articles have been published.
2) Count all articles published in those sources (a source can have multiple articles) in a given year. This statistic provides the total number of articles for that year.
3) Count the citations of each of the articles found in step two from the time of publication to the current date. Add all of the citations to get the aggregate number of citations of all articles.
4) Calculate average number of citations per article (ACPA) by dividing total number of citations by the total number of articles

$$\text{ACPA} = \frac{\text{Total Number of Citations}}{\text{Total number of articles}} \qquad (1)$$

Table 1. Sample data for calculation of average number citations per publication for Earth and Space Science (2013 and 2018)

Source	ISS Paper Count	Non-ISS Journal Paper Count 2018	Non-ISS Total Cited 2018	ISS Paper Count 2018	ISS Cited 2018	Non-ISS Journal Paper Count 2013	Non-ISS Total Cited 2013	ISS Paper Count 2013	ISS Cited 2013
Publications of the Astronomical Society of Japan	19	183	458	2	2	156	1610	1	8
Physical Review Letters	17	2861	8658	5	34	3761	106839	2	671
The Astrophysical Journal	12	3011	4565	10	15	2936	43823	1	10
Astrobiology	9	104	144	2	2	96	1328	N/A	N/A
Advances in Space Research	7	501	454	N/A	N/A	446	3531	N/A	N/A
Journal of Geophysical Research: Atmospheres	7	791	920	N/A	N/A	965	18779	4	55
Solar Physics	7	167	158	N/A	N/A	244	2515	N/A	N/A
Atmospheric Chemistry and Physics	6	961	1473	1	0	738	15145	2	11
Geophysical Research Letters	6	1490	2185	N/A	N/A	1155	23516	N/A	N/A
International Journal of Astrobiology	6	37	35	1	0	43	221	N/A	N/A
The Astrophysical Journal Letters	6	579	1517	5	5	681	14848	N/A	N/A
Total		10685	20567	26	58	11221	232155	10	755

"N/A" is used in the "ISS paper count" column for a source when no ISS articles were found in that journal for that year at the time of writing of this manuscript. Whenever N/A is used for the number of ISS paper count, N/A was also used for the number of citations corresponding to that journal and year. It's not uncommon to find ISS journal articles several years after the date of publication.

Due to the multi-disciplinary nature of ISS research, even within the same area of research, ISS papers are published in a wide range of journals. For example, as of the writing of this paper, ISS publications in the field of Earth and Space Science have been published in 97 different sources. The WOS subscription used by the authors has an analysis capability limitation of 10,000 entries at a time. To ensure apple-to-apple comparisons, the number of articles and corresponding citations used to calculate ACPA for both ISS and non-ISS articles must come same sources. The relatively small number of ISS publications is not affected by the analysis capability limitation. However, there were over eighty-five thousand (85,000) non-ISS articles in the same 97 sources in the year 2018.

Because of the 10,000 entry limitation, assessing the 85,000 non-ISS articles would have required running the analysis routines nine (9) different times in WOS, which is labor intensive. To alleviate this labor, only a portion of the 97 sources were used to estimate trends. With the goal to include as many ISS articles as possible while keeping the number of non-ISS entries to a manageable level, the sources listed in Table 1 are ordered by the total number of ISS papers, regardless of the journal's JIF or its Eigenfactor ranking.

As shown in Table 1, for 2018, the top 11 sources in terms of number of ISS articles are included in the analysis for the Earth and Space Science discipline, representing about 42 percent of all the ISS publications in this field. Those 11 sources accounted for 10,685 non-ISS articles.

Data from the 11 selected sources used to calculate ACPA are shown in table 1 for year 2018 and 2013.

For 2013, the ACPA ISS publications is 75.5 while non-ISS publications have an ACPA value of 20.69. For 2018, the ACPA values are 2.23 for ISS publications and 1.92 for non-ISS work. It should be noted that a lower value of ACPA for year 2018 than 2013 is expected because articles published in 2013 have been available to the scientific community for 5 years longer that those published in 2018.

4.2 Earth and Space Science

Following the methodology described in the previous section, the average number of citations per article is calculated for both ISS and Non-ISS publications for the discipline Earth and Space Science for each year from 2010 to 2018. The results are plotted in a graph shown in Fig. 6.

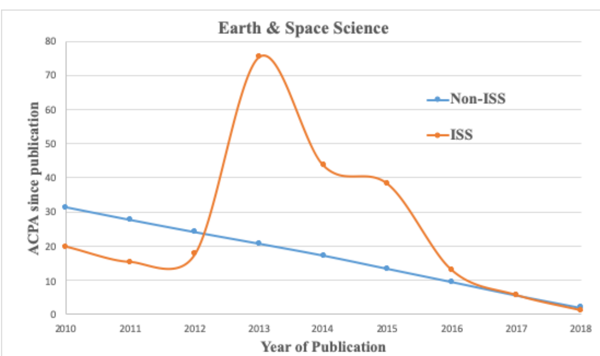

Fig. 6. Earth and Space Science average citations per article by year of publication

Fig. 6 shows ISS publications (in orange) and non-ISS publication (in blue) for the field of Earth and Space Science. The x-axis represents the year of publication, while the y-axis represents the average number of citations per article since the year of publication.

From 2010 to 2012 ISS publications had fewer citations per paper on average compared to non-ISS. Starting in 2013, the first ISS articles on the Alpha Magnetic Spectrometer–02 (AMS-02) investigation were published. The peak seen in Fig. 6 in 2013 is attributable to two of those papers published in the *Physical Review Letters* journal:

- New Limits on Dark Matter Annihilation from Alpha Magnetic Spectrometer Cosmic Ray Positron Data (cited 89 times);
- First Result from the Alpha Magnetic Spectrometer on the International Space Station: Precision Measurement of the Positron Fraction in Primary Cosmic Rays of 0.5–350 GeV (cited 582 times).

Together these papers have garnered 671 citations since publication, resulting in an average of 75.5 ISS citations per article, compared to an average of 20.69 for non-ISS work. Using the average number of citations per article metric as a measurement of the influence of scientific publication, the Fig. 6 graph implies that ISS research publications in the field of Earth and Space Science are more influential in terms of the impact on the scientific community than non-ISS peer-reviewed articles in the same field. This outcome was predictable because of the unique nature of the ISS as the only earth and space observation platform in low earth orbit.

4.3 Biology and Biotechnology

For the field of Biology and Biotechnology, ISS articles have appeared in 205 different sources thus far. Due to the limitations laid out in the previous section, only the top 15 sources in terms of number of ISS publications are included in this analysis, representing 242 articles of a total of 564, or 43 percent off all ISS articles. The yearly average number of citations per article for ISS and non-ISS publications for the period of 2010 to 2018 were calculated for the Biology and Biotechnology category and shown in Fig. 7.

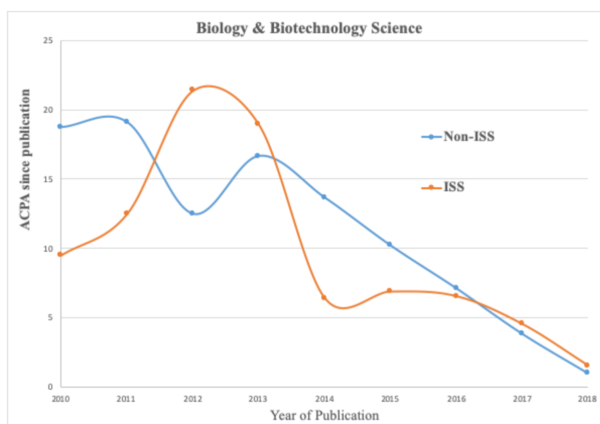

Fig. 7. Biology and Biotechnology average citations per article by year of publication

In 2010 and 2011, non-ISS articles were cited at a rate of almost 2-to-1 compared to the rate of citation of ISS publications. Then in 2013 and 2014, the trend was reversed, with ISS articles cited more often than their non-ISS counterparts. The rate of citation of ISS and non-ISS articles stabilized from 2016 to 2018, yielding a linear trend showing a comparable rate of citations per article. The authors are not able to propose theories explaining these varying averages.

Based on the limited dataset, the trend of the ACPA for ISS and non-ISS publications implies that overall, the influence (quality of publication) of ISS publications is on par with the rest of the peer-reviewed Biology and Biotechnology field.

4.4 Physical Sciences

Similar to Earth and Space Science and Biology and Biotechnology results, only the top 14 sources in terms of number of publications, which represents a threshold of a minimum of seven (7) publications per source, are included in the analysis for Physical Sciences.

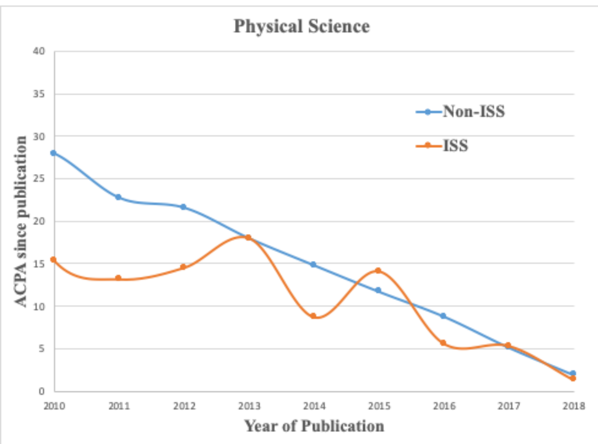

Fig. 8. Physical Science average citations per article by year of publication

Fig. 8 represents the calculated average number of citations per article for ISS and non-ISS publications for the period of 2010 to 2018 for the Physical Sciences. From 2010 through 2012, non-ISS publications performed better in terms of average citations per article. Since 2013, ISS publications have oscillated between doing better one year and worse the next in terms of the average number of citations per article than for non-ISS publications. During the same timeframe, non-ISS publications have maintained a linear trend for the average citations per article. The authors are not able to propose theories for these varying averages.

Overall, the average number of citations per article for the ISS publication is on par with non-ISS related research publication in the field of Physical Science research.

4.4 Human Research

At the time of writing, there were 133 sources with at least one ISS research results publication citation for a total of 396 ISS articles cited in the category of Human Research. With a threshold set at six publications, only 14 sources totalling 217 articles and representing 55 percent of all ISS articles in Human Research are including in this analysis.

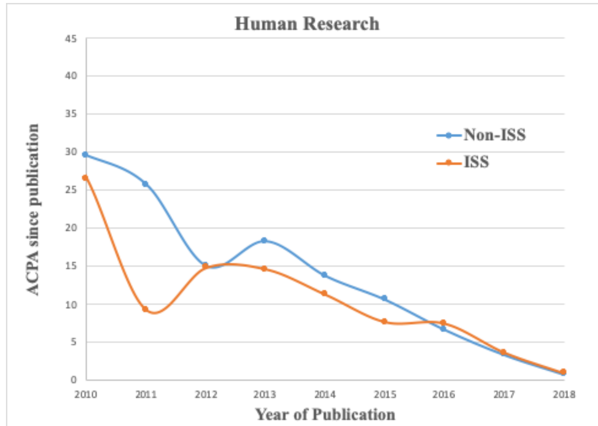

Fig. 9. Human Research average citations per article by year of publication

Fig. 9 provides the results of calculating the average number of citations per article, as presented in section 4.1, for the field of Human Research. From 2010 through 2015, non-ISS articles were cited on average at a higher or similar rate as ISS publications for the Human Research field. Starting in 2016 to 2018, both ISS and non-ISS related research articles are comparable in the average number of citations per article. Based on the latter observation, it can be stated that long-term trends suggest that interest in ISS related research is equivalent to non-ISS research within the Human Research community.

For each of the four main scientific areas of research (Earth and Space Science, Biology and Biotechnology, Physical Science, and Human Research), it can be seen that while the scientific community's interest in ISS research lagged behind its non-ISS peers from 2010 to 2012, ISS research articles published after 2013 have garnered roughly similar ACPA number of citations per article as compared to non-ISS related research publications in the same disciplines. Significantly, ISS assembly completion in March of 2011 triggered a focus on maximizing research being performed onboard ISS, which may be a factor in the increase in citations of ISS publications. Specifically in the field of Earth and Space Science, ISS publications have been cited on average at a higher rate per article than non-ISS, whereas for published ISS articles in the field of Biology and Biotech, Physical Science, and Human Research have been cited on average at a similar rate as non-ISS articles.

5. Conclusions

This paper is the first attempt by the ISS PSF to assess the impact of ISS research from the perspective of the end user (citing authors) instead of from the standpoint of measuring ISS research output. Citation data showed that ISS research output has been used by authors from every part of the globe, demonstrating that ISS impact reaches beyond ISS partner countries. Term Maps and Keyword Maps suggest that authors from areas other than the core areas of ISS research have cited ISS articles as references, including authors who have published in disciplines and subdisciplines where ISS research has neither been active nor played a major role.

The metric "average number of citations per article" shows that during the early years (2010-2012) of research, the average number of citations per article was low when compared with non-ISS publications. However, after the completion of ISS assembly, from 2013 through the present, ISS research in the field of Earth and Space Sciences tends to earn more citations per article than non-ISS papers. ISS research articles in the fields of Biology and Biotechnology, Physical Science, and Human Research tend to be cited at a similar rate as those published by non-ISS researchers.

It is worth noting that conclusions reached through the use of the metric "average number of citations per article" needs to be studied on a larger dataset. For example, the fluctuations observed in the average number of citations per ISS article curves as opposed to non-ISS publication curves suggest the small size of data available for ISS output, where a single outlier in terms of number of citations can greatly affect the overall average like the highly cited AMS papers, may skew results.

Despite the limitations outlined above, the proposed metric "average number of citations per article" to quantify the impact of ISS research results is a much more objective proxy for relative interest from other researchers in ISS findings compared with the JIF, widely used in the scientific community. Recall that JIF [17,18] is used to measure a journal's importance, not necessary the importance of the articles that are published within it. Although the concept ACPA shows potential in assessing the impact of ISS research publications on the research community, the current study needs to be broadened and repeated over the coming years as the body of ISS results builds in order to establish trends.

Acknowledgements

Contributions from ISS partners and Judy Tate Brown (MAPI) for data collection support.

Andrea Dunn, Carrie Gilder, Mary Harrison and Tracy Parr-Thumm for editorial review.

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